UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009

November 2008

ZCT 533/4 – Dosimetry and Radiation Protection
[Dosimetri dan Perlindungan Sinaran]

Duration: 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains **SEVENTEEN** printed pages before you begin the examination.
*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH BELAS** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]*

Instruction: Answer all **FOUR (4)** questions. Students are allowed to answer all questions in Bahasa Malaysia or in English.

*[**Arahan**: Jawab semua **EMPAT (4)** soalan. Pelajar dibenarkan menjawab semua soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]*

...2/-

1 a) Absorbed dose of 4 Gy to the whole body is fatal to man. The absorbed energy is distributed uniformly in a 70 kg man and there is no heat loss.
[Dos serapan 4 Gy pada keseluruhan badan biasanya memberi maut kepada manusia. Katakan tenaga setara dengan dos ini ditabarkan secara seragam di dalam seorang manusia yang beratnya 70 kg dan tiada haba yang hilang.]

i) Calculate the rise in temperature in the man.
[Hitungkan kenaikan suhu pada orang itu.]

ii) Why is the dose fatal to man although the temperature rise is small?
[Mengapakah dos ini membawa maut kepada manusia walaupun kenaikan suhunya hanya kecil saja?]

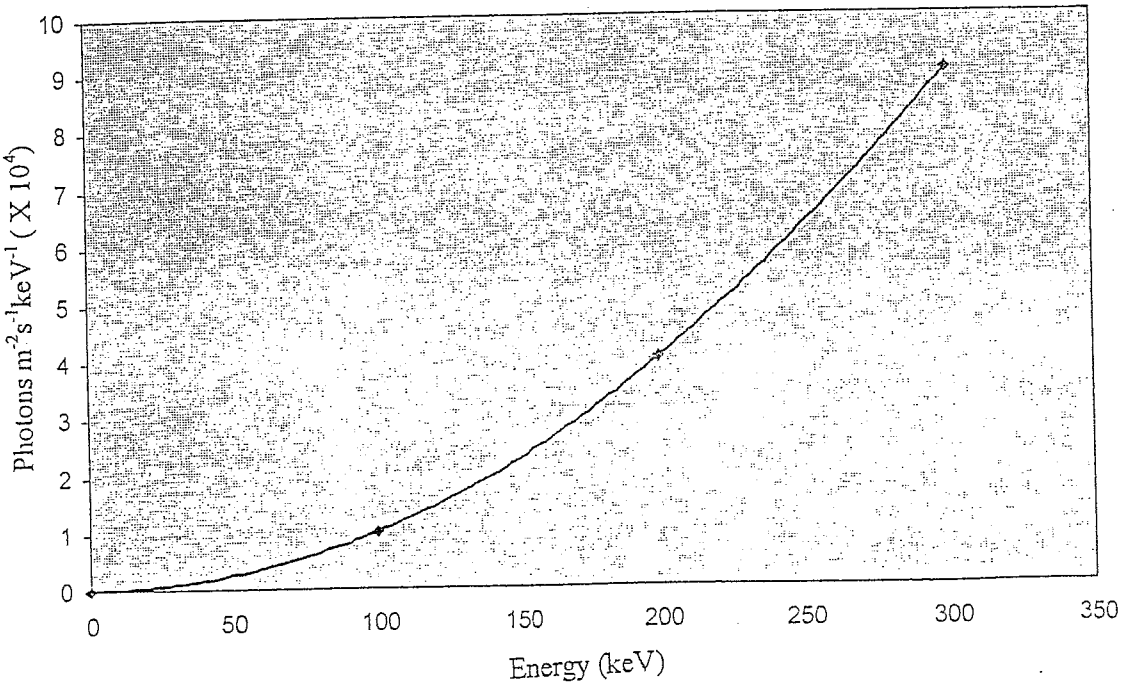
Assume specific heat of man is similar to specific heat of water i.e.
$s = 4200 \text{ J kg}^{-1} \text{ K}^{-1}$
[Andaikan spesifik manusia sama dengan haba spesifik air iaitu $s = 4200 \text{ J kg}^{-1} \text{ K}^{-1}$*.]*

(30/100)

b) Explain the difference between mass attenuation coefficient and mass stopping power.
[Terangkan perbezaan antara pekali pengecilan jisim dan kuasa penghentian jisim]

(20/100)

c)



i) Calculate the total fluence.
[Hitungkan jumlah fluens]

ii) Plot the differential flux density against energy in the graph provided.
[Plotkan ketumpatan fluks tenaga diferensial pada tenaga dalam graf yang diberi]

iii) Calculate the total energy fluence.
[Hitungkan jumlah tenaga fluens]

iv) Calculate the mean photon energy with respect to fluence.
[Hitungkan tenaga purata foton merujuk pada fluens]

v) Calculate the absorbed dose in water where the fluence passes through it. State any assumptions used.
[Hitungkan dos serapan dalam air jika fluens foton melaluinya. Nyatakan sebarang anggapan yang digunakan.]

(50/100)

2 a) State Bragg-Gray theory and its assumptions.
[Nyatakan teorem Bragg – Gray dan anggapannnya.]

(25/100)

b) Explain the differences and similarities between Spencer theory and Bragg-Gray theory.
[Terangkan perbezaan dan kesamaan antara teori Spencer dan teori Bragg – Gray]

(25/100)

...4/-

c) A beam of electrons whose fluence is 2 x 10^{10} cm^{-2} hits a LiF chip perpendicularly. Thickness of chip is 1.0 mm and the surface area is 3.0 x 3.0 mm^2. Calculate the absorbed dose in chip if the energy of electron is (i) 300 keV and (ii) 2 MeV. Explain your answers. Assume path lengthening of electron in LiF is 5%.
[Bim elektron yang fluensnya 2 x 10^{10} cm^{-2} menghentam suatu cip LiF secara bertegak lurus. Ketebalan cipnya 1.0 mm dan luasnya 3.0 x 3.0 mm^2 . Hitungkan dos serapan dalam cip jika tenaga elektronnya (i) 300 keV dan (ii) 2 MeV. Jelaskan jawapan anda. Anggapkan pemanjangan lintasan elektron dalam LiF ialah 5 %.]

(50/100)

3 a) A calibrated ion chamber is used to calibrate a 6 MV photon beam in water. The ion chamber gave a reading of Y nC at 5 cm depth in the water phantom. Discuss the varions corrections that are applied to obtain the dose at d_{max} from the ion chamber reading.
[Suatu kebuk pengionan yang ditentukur digunakan untuk menentukur 6 MV bim foton dalam air. Kebuk pengionan memberi bacaan Y nC pada kedalaman 5 cm dalam fantom air. Bincangkan pembetulan-pembetulan yang perlu dilaksanakan untuk mendapat dos pada d_{max} dari bacaan kebuk pengionan.]

(50/100)

b) A perspex phantom is used to calibrate a 6 MV photon beam. A cylindrical air ion chamber has a wall thickness (polystyrene) of 0.20 g cm^{-2} and an inner diameter of 5 mm. The ion chamber is placed at a depth of 5 cm in the phantom. N_xA_{ion}= 1.05 x 10^{10} R/C (T = 22 °C , P = 760 torr) for Co – 60 for this chamber. Charge collected is 2.50 x 10^{-8} C at P = 750 torr & T = 20.0 °C and the ion collection efficiency is 0.985.
[Suatu fantom perspek digunakan untuk mententukur bim foton 6 MV. Suatu kebuk pengionan udara berbentuk silinder mempunyai ketebalan dinding (polystyrene) 0.20 g cm^{-2} dan garis pusat dalaman 5 mm. Kebuk pengionan di letak 5 cm dalam fantom, $N_x A_{ion}$ = 1.05 x 10^{10} R/C (T = 22 °C , P = 760 torr) bagi Co – 60 untuk kebuk ini. Cas pengumpulannya ialah 2.50 x 10^{-8} C pada P = 750 torr & T = 20.0 °C dan kecekapan pengumpulan ion = 0.985]

i) Calculate the N_{Dair} the chamber.
[Hitungkan N_{Dudara} bagi kebuk ini.]

...5/-

ii) Calculate the absorbed dose in perspex at this depth.
[Hitungkan dos serapan dalam perspek pada kedalaman ini.]

State any assumptions.
[Nyatakan andaian-andaian]
$\beta_w = 1.003$

$(\frac{\bar{L}}{\rho})^{air}_{polystyrene} = 0.904\ (Co-60)$

$(\frac{\bar{L}}{\rho})^{perspex}_{air} = 1.093 \quad (6\,\text{MV}\ photon)$

$(\frac{\bar{L}}{\rho})^{perspex}_{polystyrene} = 1.103\ (6\,\text{MV}\ photon)$

(50/100)

4 a) Discuss briefly the interaction between
[Bincangkan secara ringkas tindakbalas antara]

i) Thermal neutron and tissue.
[neutron terma dengan tisu]

ii) Fast neutron and tissue.
[neutron cepat dengan tisu]

(30/100)

b) Discuss briefly the thermo luminescence processes that occur in a LiF chip.
[Bincangkan secara ringkas proses-proses termoluminesens yang berlaku dalam suatu cip LiF]

(35/100)

c) State the differences between stochastic and deterministic effects in radiation protection. Which effect has greater importance in radiation protection? Why?
[Nyatakan perbezaan antara kesan stokastik dan deterministik dalam perlindungan sinaran. Kesan manakah yang lebih penting dalam perlindungan sinaran? Mengapa?]

(35/100)

...6/-

Appendix B.2. Data Table for Compounds and Mixtures[a]

Material	Density (g/cm^3)[c]	Electron density (10^{23} e/g)	I (eV)[d]
A-150 plastic[b]	1.127	3.306	65.1
Adipose tissue (Fat, ICRP)[b]	0.92	3.363	63.2
Air[b]	1.205×10^{-3}	3.006	85.7
Bone, cortical (ICRP)[b]	1.85	3.139	106.4
Calcium fluoride, CaF_2	3.18	2.931	166
Carbon dioxide, CO_2	1.842×10^{-3}	3.010	85.0
Cesium iodide, CsI	4.51	2.503	553
Lithium fluoride, LiF	2.64	2.786	94.0
Lucite, $(C_5H_8O_2)_n$	1.19	3.248	74.0
Muscle, skeletal (ICRP)[b]	1.04	3.308	75.3
Mylar, $(C_{10}H_8O_4)_n$	1.40	3.134	78.7
Nylon, type 6 $(C_6H_{11}NO)_n$	1.14	3.299	63.9
Polycarbonate $(C_{16}H_{14}O_3)_n$	1.20	3.173	73.1
Polyethylene $(C_2H_4)_n$	0.94	3.435	57.4
Polyimide $(C_{22}H_{10}N_2O_5)$	1.42	3.087	79.6
Polypropylene $(C_3H_5)_n$	0.90	3.372	59.2
Polystyrene $(C_8H_8)_n$	1.06	3.238	68.7
Polyvinyl Chloride $(C_2H_3Cl)_n$	1.30	3.083	108.2
Pyrex (borosilicate glass)[b]	2.23	2.993	134
Silicon dioxide, SiO_2	2.32	3.007	139.2
Silver bromide, AgBr	6.47	2.629	487
Sodium iodide, NaI	3.67	2.571	452
Teflon, $(C_2F_4)_n$	2.20	2.890	99.1
TE gas (methane-based)[b]	1.064×10^{-3}	3.312	61.2
TE gas (propane-based)[b]	1.826×10^{-3}	3.314	59.5
TE liquid (no sucrose)[b]	1.070	3.313	74.2
Water, H_2O	0.9982	3.343	75.0

[a] Data from Berger and Seltzer (1983)

[b] See compositions in Appendix B.3

[c] Assuming $T = 20°C.$, $P = 1$ atm., and Charles' Law for gases applies.

[d] I is the mean excitation potential for stopping power, see Chapter 8.

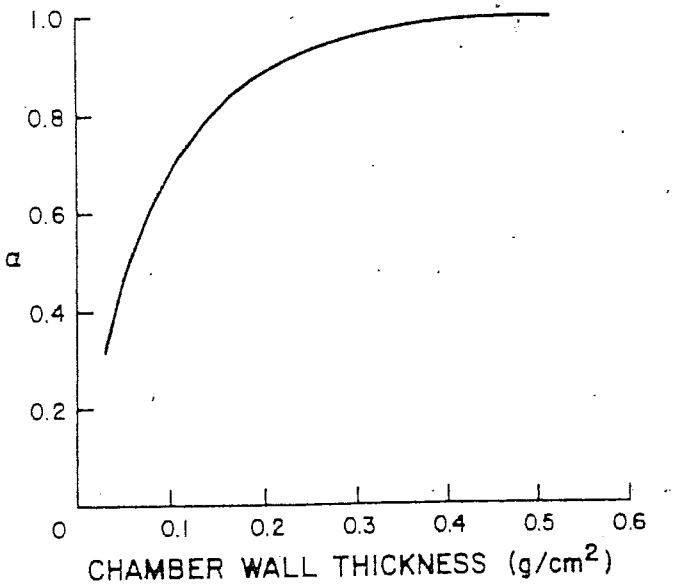


FIGURE 13.7*a*. Fraction α of ionization due to electrons arising in the chamber wall, as a function of mass wall thickness, for ^{60}Co γ-rays [Lempert et al. (1983), as adapted by AAPM (1983)]. Reproduced with permission from R. J. Schulz and The American Institute of Physics.

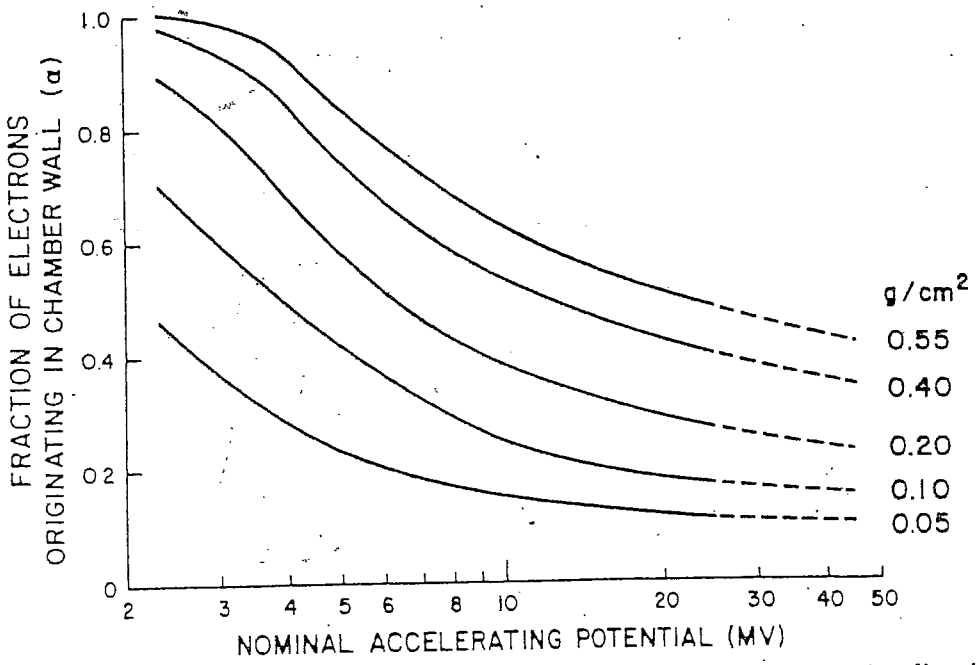


FIGURE 13.7*b*. Fraction α of ionization due to electrons from the chamber wall irradiated by x-rays with nominal acceleration potentials of 2 to 50 MV. The dashed portions of the curves are extrapolations of the experimental data. [Lempert et al. (1983), as adapted by AAPM (1983). Reproduced with permission from R. J. Schulz and The American Institute of Physics.]

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APPENDIX D.3. *(Continued)*

Photon Energy (MeV)	Air			Water			ICRU Compact Bone			ICRU Striated Muscle		
	μ/ρ	μ_{tr}/ρ	μ_{en}/ρ	μ/ρ	μ_{tr}/ρ	μ_{en}/ρ	μ/ρ	μ_{tr}/ρ	μ_{en}/ρ	μ/ρ	μ_{tr}/ρ	μ_{en}/ρ
0.01	5.04	4.61	4.61	5.21	4.79	4.79	20.3	19.2	19.2	5.30	4.87	4.87
0.015	1.56	1.27	1.27	1.60	1.28	1.28	6.32	5.84	5.84	1.64	1.32	1.32
0.02	0.758	0.511	0.511	0.778	0.512	0.512	2.79	2.46	2.46	0.796	0.533	0.533
0.03	0.350	0.148	0.148	0.371	0.149	0.149	0.962	0.720	0.720	0.375	0.154	0.154
0.04	0.248	0.0668	0.0668	0.267	0.0677	0.0677	0.511	0.304	0.304	0.267	0.0701	0.0701
0.05	0.206	0.0406	0.0406	0.225	0.0418	0.0418	0.346	0.161	0.161	0.224	0.0431	0.0431
0.06	0.187	0.0305	0.0305	0.205	0.0320	0.0320	0.273	0.0998	0.0998	0.204	0.0328	0.0328
0.08	0.167	0.0243	0.0243	0.185	0.0262	0.0262	0.209	0.0537	0.0537	0.183	0.0264	0.0264
0.10	0.155	0.0234	0.0234	0.171	0.0256	0.0256	0.181	0.0387	0.0387	0.170	0.0256	0.0256
0.15	0.136	0.0250	0.0250	0.151	0.0277	0.0277	0.150	0.0305	0.0305	0.150	0.0275	0.0275
0.2	0.124	0.0268	0.0268	0.137	0.0297	0.0297	0.133	0.0301	0.0301	0.136	0.0294	0.0294
0.3	0.107	0.0287	0.0287	0.119	0.0319	0.0319	0.114	0.0310	0.0310	0.118	0.0317	0.0317
0.4	0.0954	0.0295	0.0295	0.106	0.0328	0.0328	0.102	0.0315	0.0315	0.105	0.0325	0.0325
0.5	0.0868	0.0297	0.0296	0.0966	0.0330	0.0330	0.0926	0.0317	0.0317	0.0958	0.0328	0.0328
0.6	0.0804	0.0296	0.0295	0.0894	0.0329	0.0329	0.0856	0.0315	0.0314	0.0886	0.0326	0.0325
0.8	0.0706	0.0289	0.0289	0.0785	0.0321	0.0321	0.0751	0.0307	0.0306	0.0778	0.0318	0.0318
1.0	0.0635	0.0280	0.0278	0.0706	0.0311	0.0309	0.0675	0.0297	0.0295	0.0699	0.0308	0.0306
1.5	0.0517	0.0256	0.0254	0.0575	0.0284	0.0282	0.0549	0.0272	0.0270	0.0570	0.0282	0.0280
2	0.0444	0.0236	0.0234	0.0493	0.0262	0.0260	0.0472	0.0251	0.0249	0.0489	0.0259	0.0257
3	0.0358	0.0207	0.0205	0.0396	0.0229	0.0227	0.0382	0.0221	0.0219	0.0392	0.0227	0.0225
4	0.0308	0.0189	0.0186	0.0340	0.0209	0.0206	0.0331	0.0204	0.0200	0.0337	0.0207	0.0204
5	0.0276	0.0178	0.0174	0.0303	0.0195	0.0191	0.0297	0.0192	0.0187	0.0300	0.0193	0.0189
6	0.0252	0.0168	0.0164	0.0277	0.0185	0.0180	0.0274	0.0184	0.0178	0.0274	0.0183	0.0178
8	0.0223	0.0157	0.0152	0.0243	0.0170	0.0166	0.0244	0.0173	0.0167	0.0240	0.0169	0.0164
10	0.0205	0.0151	0.0145	0.0222	0.0162	0.0157	0.0226	0.0168	0.0159	0.0219	0.0160	0.0155

APPENDIX D.4. Mass Energy-Absorption Coefficients μ_{en}/ρ (cm^2/g) for Various Media[a]

γ-Ray Energy (MeV)	Li	F	LiF	Teflon $(CF_2)_n$	CaF_2	$CaF_2:Mn$[b]
0.01	0.150	7.61	5.61	6.26	50.7	51.7
0.015	0.0426	2.05	1.51	1.69	15.7	16.1
0.02	0.0205	0.821	0.607	0.674	6.66	6.86
0.03	0.0118	0.233	0.174	0.191	1.96	2.03
0.04	0.0115	0.100	0.0763	0.0833	0.818	0.850
0.05	0.0125	0.0566	0.0448	0.0486	0.419	0.436
0.06	0.0137	0.0391	0.0323	0.0348	0.247	0.256
0.08	0.0159	0.0270	0.0240	0.0254	0.114	0.118
0.10	0.0178	0.0241	0.0224	0.0235	0.0677	0.0697
0.15	0.0210	0.0243	0.0234	0.0243	0.0373	0.0379
0.2	0.0229	0.0256	0.0249	0.0258	0.0315	0.0317
0.3	0.0248	0.0273	0.0266	0.0276	0.0296	0.0296
0.4	0.0255	0.0281	0.0274	0.0284	0.0295	0.0295
0.5	0.0258	0.0282	0.0276	0.0286	0.0293	0.0293
0.6	0.0256	0.0281	0.0274	0.0284	0.0290	0.0290
0.8	0.0250	0.0273	0.0267	0.0277	0.0281	0.0281
1.0	0.0242	0.0264	0.0258	0.0268	0.0271	0.0270
1.5	0.0221	0.0241	0.0236	0.0244	0.0248	0.0247
2.0	0.0203	0.0222	0.0217	0.0225	0.0229	0.0229
3.0	0.0175	0.0196	0.0190	0.0198	0.0205	0.0205
4.0	0.0156	0.0179	0.0173	0.0180	0.0192	0.0192
5.0	0.0142	0.0168	0.0161	0.0169	0.0184	0.0184
6.0	0.0131	0.0160	0.0152	0.0160	0.0179	0.0179
8.0	0.0117	0.0150	0.0141	0.0149	0.0175	0.0175
10.0	0.0107	0.0144	0.0134	0.0143	0.0173	0.0173

[a]Data for Li, F, LiF, and Teflon are taken from Sinclair (1969); those for CaF_2 and CaF_2:Mn are from Attix (1970). Both references were derived from the data of J. H. Hubbell, as published in the review by Evans (1968).
[b]CaF_2:Mn (TLD phosphor) is 49.5% Ca, 48.4% F, and 2.1% Mn by weight.

APPENDIX D.3. *(Continued)*

Photon Energy (MeV)	Polystyrene			Methyl Methacrylate, Lucite, Plexiglas, Perspex			Polyethylene			Pyrex glass		
	μ/ρ	μ_{tr}/ρ	μ_{en}/ρ	μ/ρ	μ_{tr}/ρ	μ_{en}/ρ	μ/ρ	μ_{tr}/ρ	μ_{en}/ρ	μ/ρ	μ_{tr}/ρ	μ_{en}/ρ
0.01	2.17	1.82	1.82	3.31	2.91	2.91	2.04	1.69	1.69	17.1	16.5	16.5
0.015	0.764	0.495	0.495	1.07	0.783	0.783	0.737	0.461	0.461	5.11	4.75	4.75
0.02	0.429	0.193	0.193	0.555	0.310	0.310	0.425	0.180	0.180	2.24	1.94	1.94
0.03	0.261	0.0562	0.0562	0.300	0.0899	0.0899	0.268	0.0535	0.0535	0.785	0.554	0.554
0.04	0.216	0.0300	0.0300	0.233	0.0437	0.0437	0.225	0.0295	0.0295	0.430	0.232	0.232
0.05	0.197	0.0236	0.0236	0.205	0.0301	0.0301	0.207	0.0238	0.0238	0.299	0.122	0.122
0.06	0.186	0.0218	0.0218	0.191	0.0254	0.0254	0.196	0.0225	0.0225	0.241	0.0768	0.0768
0.08	0.173	0.0217	0.0217	0.176	0.0232	0.0232	0.183	0.0228	0.0228	0.190	0.0428	0.0428
0.10	0.164	0.0231	0.0231	0.165	0.0238	0.0238	0.173	0.0243	0.0243	0.166	0.0325	0.0325
0.15	0.145	0.0263	0.0263	0.146	0.0266	0.0266	0.154	0.0279	0.0279	0.139	0.0274	0.0274
0.2	0.132	0.0286	0.0286	0.133	0.0287	0.0287	0.140	0.0303	0.0303	0.125	0.0276	0.0276
0.3	0.115	0.0309	0.0309	0.115	0.0310	0.0310	0.122	0.0328	0.0328	0.107	0.0289	0.0289
0.4	0.103	0.0318	0.0318	0.103	0.0318	0.0318	0.109	0.0337	0.0337	0.0953	0.0295	0.0295
0.5	0.0937	0.0321	0.0321	0.0939	0.0322	0.0322	0.0994	0.0340	0.0340	0.0868	0.0297	0.0297
0.6	0.0867	0.0319	0.0318	0.0869	0.0319	0.0319	0.0919	0.0338	0.0337	0.0801	0.0295	0.0294
0.8	0.0761	0.0311	0.0310	0.0763	0.0312	0.0311	0.0807	0.0330	0.0329	0.0704	0.0288	0.0287
1.0	0.0683	0.0300	0.0300	0.0686	0.0302	0.0301	0.0725	0.0319	0.0319	0.0633	0.0279	0.0277
1.5	0.0557	0.0275	0.0275	0.0559	0.0276	0.0275	0.0591	0.0292	0.0291	0.0515	0.0254	0.0252
2	0.0476	0.0253	0.0252	0.0478	0.0254	0.0253	0.0505	0.0268	0.0267	0.0444	0.0235	0.0233
3	0.0381	0.0221	0.0219	0.0383	0.0222	0.0220	0.0403	0.0234	0.0232	0.0360	0.0209	0.0207
4	0.0326	0.0200	0.0198	0.0329	0.0202	0.0199	0.0345	0.0211	0.0209	0.0314	0.0194	0.0190
5	0.0289	0.0185	0.0182	0.0292	0.0187	0.0184	0.0305	0.0195	0.0192	0.0284	0.0184	0.0179
6	0.0263	0.0174	0.0171	0.0266	0.0177	0.0173	0.0276	0.0182	0.0180	0.0263	0.0178	0.0171
8	0.0227	0.0159	0.0155	0.0231	0.0162	0.0158	0.0238	0.0166	0.0162	0.0237	0.0170	0.0163
10	0.0206	0.0150	0.0145	0.0210	0.0153	0.0148	0.0215	0.0155	0.0151	0.0221	0.0166	0.0157

...13/-

APPENDIX E. (*Continued*)

Polystyrene

ENERGY.	STOPPING POWER COLLISION	STOPPING POWER RADIATIVE	TOTAL	CSDA RANGE	RADIATION YIELD	DENS.EFF. CORR. (DELTA)
MeV	MeV cm²/g	MeV cm²/g	MeV cm²/g	g/cm²		
0.0100	2.223E+01	2.982E-03	2.224E+01	2.546E-04	7.406E-05	0.0
0.0125	1.868E+01	2.992E-03	1.869E+01	3.777E-04	8.869E-05	0.0
0.0150	1.621E+01	2.999E-03	1.621E+01	5.218E-04	1.027E-04	0.0
0.0175	1.437E+01	3.004E-03	1.438E+01	6.859E-04	1.162E-04	0.0
0.0200	1.296E+01	3.008E-03	1.296E+01	8.694E-04	1.292E-04	0.0
0.0250	1.091E+01	3.017E-03	1.091E+01	1.292E-03	1.543E-04	0.0
0.0300	9.485E+00	3.027E-03	9.488E+00	1.785E-03	1.782E-04	0.0
0.0350	8.440E+00	3.037E-03	8.443E+00	2.345E-03	2.013E-04	0.0
0.0400	7.637E+00	3.048E-03	7.640E+00	2.968E-03	2.235E-04	0.0
0.0450	7.000E+00	3.061E-03	7.003E+00	3.653E-03	2.452E-04	0.0
0.0500	6.481E+00	3.074E-03	6.484E+00	4.395E-03	2.662E-04	0.0
0.0550	6.051E+00	3.088E-03	6.054E+00	5.194E-03	2.867E-04	0.0
0.0600	5.688E+00	3.103E-03	5.691E+00	6.047E-03	3.068E-04	0.0
0.0700	5.108E+00	3.135E-03	5.111E+00	7.905E-03	3.458E-04	0.0
0.0800	4.666E+00	3.169E-03	4.669E+00	9.955E-03	3.834E-04	0.0
0.0900	4.317E+00	3.206E-03	4.320E+00	1.218E-02	4.197E-04	0.0
0.1000	4.034E+00	3.244E-03	4.038E+00	1.458E-02	4.550E-04	0.0
0.1250	3.520E+00	3.350E-03	3.523E+00	2.124E-02	5.396E-04	0.0
0.1500	3.172E+00	3.463E-03	3.176E+00	2.873E-02	6.199E-04	0.0
0.1750	2.923E+00	3.584E-03	2.926E+00	3.695E-02	6.967E-04	0.0
0.2000	2.735E+00	3.711E-03	2.739E+00	4.579E-02	7.709E-04	0.0
0.2500	2.475E+00	3.985E-03	2.479E+00	6.504E-02	9.131E-04	0.0
0.3000	2.305E+00	4.284E-03	2.309E+00	8.598E-02	1.050E-03	0.0
0.3500	2.187E+00	4.604E-03	2.192E+00	1.082E-01	1.182E-03	0.0
0.4000	2.101E+00	4.945E-03	2.106E+00	1.315E-01	1.312E-03	2.729E-03
0.4500	2.035E+00	5.304E-03	2.040E+00	1.557E-01	1.441E-03	2.688E-02
0.5000	1.984E+00	5.680E-03	1.990E+00	1.805E-01	1.570E-03	5.420E-02
0.5500	1.943E+00	6.071E-03	1.950E+00	2.059E-01	1.699E-03	8.383E-02
0.6000	1.911E+00	6.475E-03	1.918E+00	2.318E-01	1.827E-03	1.152E-01
0.7000	1.864E+00	7.322E-03	1.871E+00	2.846E-01	2.087E-03	1.810E-01
0.8000	1.832E+00	8.212E-03	1.840E+00	3.385E-01	2.349E-03	2.492E-01
0.9000	1.810E+00	9.142E-03	1.819E+00	3.932E-01	2.615E-03	3.179E-01
1.0000	1.794E+00	1.011E-02	1.804E+00	4.484E-01	2.885E-03	3.862E-01
1.2500	1.773E+00	1.267E-02	1.786E+00	5.878E-01	3.577E-03	5.515E-01
1.5000	1.766E+00	1.541E-02	1.781E+00	7.281E-01	4.293E-03	7.064E-01
1.7500	1.765E+00	1.830E-02	1.783E+00	8.684E-01	5.030E-03	8.501E-01
2.0000	1.768E+00	2.132E-02	1.789E+00	1.008E+00	5.788E-03	9.834E-01
2.5000	1.778E+00	2.766E-02	1.806E+00	1.287E+00	7.352E-03	1.222E+00
3.0000	1.791E+00	3.435E-02	1.825E+00	1.562E+00	8.970E-03	1.431E+00
3.5000	1.804E+00	4.132E-02	1.845E+00	1.835E+00	1.063E-02	1.616E+00
4.0000	1.816E+00	4.852E-02	1.865E+00	2.104E+00	1.233E-02	1.782E+00
4.5000	1.828E+00	5.593E-02	1.884E+00	2.371E+00	1.405E-02	1.932E+00
5.0000	1.839E+00	6.353E-02	1.902E+00	2.635E+00	1.580E-02	2.070E+00
5.5000	1.849E+00	7.129E-02	1.920E+00	2.897E+00	1.757E-02	2.197E+00
6.0000	1.859E+00	7.919E-02	1.938E+00	3.156E+00	1.936E-02	2.316E+00
7.0000	1.876E+00	9.539E-02	1.971E+00	3.667E+00	2.297E-02	2.531E+00
8.0000	1.891E+00	1.120E-01	2.003E+00	4.171E+00	2.662E-02	2.722E+00
9.0000	1.904E+00	1.290E-01	2.033E+00	4.666E+00	3.029E-02	2.896E+00
10.0000	1.916E+00	1.464E-01	2.062E+00	5.155E+00	3.399E-02	3.054E+00
12.5000	1.940E+00	1.909E-01	2.131E+00	6.347E+00	4.325E-02	3.403E+00
15.0000	1.960E+00	2.367E-01	2.196E+00	7.502E+00	5.249E-02	3.702E+00
17.5000	1.975E+00	2.835E-01	2.259E+00	8.625E+00	6.166E-02	3.963E+00
20.0000	1.989E+00	3.311E-01	2.320E+00	9.717E+00	7.072E-02	4.196E+00
25.0000	2.010E+00	4.282E-01	2.439E+00	1.182E+01	8.844E-02	4.596E+00
30.0000	2.027E+00	5.270E-01	2.554E+00	1.382E+01	1.056E-01	4.933E+00
35.0000	2.041E+00	6.271E-01	2.669E+00	1.574E+01	1.220E-01	5.223E+00
40.0000	2.053E+00	7.284E-01	2.782E+00	1.757E+01	1.378E-01	5.478E+00
45.0000	2.064E+00	8.306E-01	2.894E+00	1.933E+01	1.530E-01	5.704E+00
50.0000	2.073E+00	9.334E-01	3.006E+00	2.103E+01	1.676E-01	5.908E+00
55.0000	2.081E+00	1.037E+00	3.118E+00	2.266E+01	1.816E-01	6.093E+00
60.0000	2.089E+00	1.141E+00	3.230E+00	2.424E+01	1.951E-01	6.263E+00
70.0000	2.102E+00	1.351E+00	3.452E+00	2.723E+01	2.204E-01	6.565E+00
80.0000	2.113E+00	1.562E+00	3.675E+00	3.004E+01	2.439E-01	6.828E+00
90.0000	2.123E+00	1.774E+00	3.897E+00	3.268E+01	2.658E-01	7.060E+00

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APPENDIX E. (*Continued*)

Air (Dry)

ENERGY	STOPPING POWER COLLISION	STOPPING POWER RADIATIVE	STOPPING POWER TOTAL	CSDA RANGE	RADIATION YIELD	DENS.EFF. CORR. (DELTA)
MeV	MeV cm²/g	MeV cm²/g	MeV cm²/g	g/cm²		
0.0100	1.975E+01	3.897E-03	1.976E+01	2.883E-04	1.082E-04	0.0
0.0125	1.663E+01	3.921E-03	1.663E+01	4.269E-04	1.299E-04	0.0
0.0150	1.445E+01	3.937E-03	1.445E+01	5.886E-04	1.506E-04	0.0
0.0175	1.283E+01	3.946E-03	1.283E+01	7.726E-04	1.706E-04	0.0
0.0200	1.157E+01	3.954E-03	1.158E+01	9.781E-04	1.898E-04	0.0
0.0250	9.753E+00	3.966E-03	9.757E+00	1.451E-03	2.267E-04	0.0
0.0300	8.492E+00	3.976E-03	8.496E+00	2.001E-03	2.618E-04	0.0
0.0350	7.563E+00	3.986E-03	7.567E+00	2.626E-03	2.955E-04	0.0
0.0400	6.848E+00	3.998E-03	6.852E+00	3.322E-03	3.280E-04	0.0
0.0450	6.281E+00	4.011E-03	6.285E+00	4.085E-03	3.594E-04	0.0
0.0500	5.819E+00	4.025E-03	5.823E+00	4.912E-03	3.900E-04	0.0
0.0550	5.435E+00	4.040E-03	5.439E+00	5.801E-03	4.197E-04	0.0
0.0600	5.111E+00	4.057E-03	5.115E+00	6.750E-03	4.488E-04	0.0
0.0700	4.593E+00	4.093E-03	4.597E+00	8.817E-03	5.049E-04	0.0
0.0800	4.198E+00	4.133E-03	4.202E+00	1.110E-02	5.590E-04	0.0
0.0900	3.886E+00	4.175E-03	3.890E+00	1.357E-02	6.112E-04	0.0
0.1000	3.633E+00	4.222E-03	3.637E+00	1.623E-02	6.618E-04	0.0
0.1250	3.172E+00	4.348E-03	3.177E+00	2.362E-02	7.826E-04	0.0
0.1500	2.861E+00	4.485E-03	2.865E+00	3.193E-02	8.968E-04	0.0
0.1750	2.637E+00	4.633E-03	2.642E+00	4.103E-02	1.006E-03	0.0
0.2000	2.470E+00	4.789E-03	2.474E+00	5.082E-02	1.111E-03	0.0
0.2500	2.236E+00	5.126E-03	2.242E+00	7.212E-02	1.311E-03	0.0
0.3000	2.084E+00	5.495E-03	2.089E+00	9.527E-02	1.502E-03	0.0
0.3500	1.978E+00	5.890E-03	1.984E+00	1.199E-01	1.688E-03	0.0
0.4000	1.902E+00	6.311E-03	1.908E+00	1.456E-01	1.869E-03	0.0
0.4500	1.845E+00	6.757E-03	1.852E+00	1.722E-01	2.048E-03	0.0
0.5000	1.802E+00	7.223E-03	1.809E+00	1.995E-01	2.225E-03	0.0
0.5500	1.769E+00	7.708E-03	1.776E+00	2.274E-01	2.401E-03	0.0
0.6000	1.743E+00	8.210E-03	1.751E+00	2.558E-01	2.577E-03	0.0
0.7000	1.706E+00	9.258E-03	1.715E+00	3.135E-01	2.929E-03	0.0
0.8000	1.683E+00	1.036E-02	1.694E+00	3.722E-01	3.283E-03	0.0
0.9000	1.669E+00	1.151E-02	1.681E+00	4.315E-01	3.638E-03	0.0
1.0000	1.661E+00	1.271E-02	1.674E+00	4.912E-01	3.997E-03	0.0
1.2500	1.655E+00	1.588E-02	1.671E+00	6.408E-01	4.906E-03	0.0
1.5000	1.661E+00	1.927E-02	1.680E+00	7.900E-01	5.836E-03	0.0
1.7500	1.672E+00	2.284E-02	1.696E+00	9.382E-01	6.784E-03	0.0
2.0000	1.684E+00	2.656E-02	1.711E+00	1.085E+00	7.748E-03	0.0
2.5000	1.712E+00	3.437E-02	1.747E+00	1.374E+00	9.716E-03	0.0
3.0000	1.740E+00	4.260E-02	1.783E+00	1.658E+00	1.173E-02	0.0
3.5000	1.766E+00	5.115E-02	1.817E+00	1.935E+00	1.377E-02	0.0
4.0000	1.790E+00	5.999E-02	1.850E+00	2.208E+00	1.583E-02	0.0
4.5000	1.812E+00	6.908E-02	1.882E+00	2.476E+00	1.792E-02	0.0
5.0000	1.833E+00	7.838E-02	1.911E+00	2.740E+00	2.001E-02	0.0
5.5000	1.852E+00	8.787E-02	1.940E+00	2.999E+00	2.211E-02	0.0
6.0000	1.870E+00	9.754E-02	1.968E+00	3.255E+00	2.422E-02	0.0
7.0000	1.902E+00	1.173E-01	2.020E+00	3.757E+00	2.845E-02	0.0
8.0000	1.931E+00	1.376E-01	2.068E+00	4.246E+00	3.269E-02	0.0
9.0000	1.956E+00	1.584E-01	2.115E+00	4.724E+00	3.692E-02	0.0
10.0000	1.979E+00	1.795E-01	2.159E+00	5.192E+00	4.113E-02	0.0
12.5000	2.029E+00	2.337E-01	2.262E+00	6.323E+00	5.156E-02	0.0
15.0000	2.069E+00	2.895E-01	2.359E+00	7.405E+00	6.181E-02	0.0
17.5000	2.104E+00	3.464E-01	2.451E+00	8.444E+00	7.185E-02	0.0
20.0000	2.134E+00	4.042E-01	2.539E+00	9.446E+00	8.167E-02	0.0
25.0000	2.185E+00	5.219E-01	2.707E+00	1.135E+01	1.006E-01	0.0
30.0000	2.226E+00	6.417E-01	2.868E+00	1.315E+01	1.186E-01	7.636E-03
35.0000	2.257E+00	7.630E-01	3.020E+00	1.485E+01	1.357E-01	5.984E-02
40.0000	2.282E+00	8.855E-01	3.167E+00	1.646E+01	1.520E-01	1.378E-01
45.0000	2.302E+00	1.009E+00	3.311E+00	1.801E+01	1.676E-01	2.266E-01
50.0000	2.319E+00	1.133E+00	3.452E+00	1.948E+01	1.825E-01	3.192E-01
55.0000	2.334E+00	1.258E+00	3.592E+00	2.090E+01	1.968E-01	4.120E-01
60.0000	2.347E+00	1.384E+00	3.731E+00	2.227E+01	2.104E-01	5.029E-01
70.0000	2.369E+00	1.637E+00	4.006E+00	2.486E+01	2.361E-01	6.762E-01
80.0000	2.387E+00	1.892E+00	4.279E+00	2.727E+01	2.598E-01	8.365E-01
90.0000	2.403E+00	2.148E+00	4.551E+00	2.954E+01	2.818E-01	9.842E-01

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APPENDIX E. (*Continued*)

Water (Liquid)

ENERGY	STOPPING POWER COLLISION	STOPPING POWER RADIATIVE	STOPPING POWER TOTAL	CSDA RANGE	RADIATION YIELD	DENS. EFF. CORR. (DELTA)
MeV	MeV cm²/g	MeV cm²/g	MeV cm²/g	g/cm²		
0.0100	2.256E+01	3.898E-03	2.257E+01	2.515E-04	9.408E-05	0.0
0.0125	1.897E+01	3.927E-03	1.898E+01	3.728E-04	1.133E-04	0.0
0.0150	1.647E+01	3.944E-03	1.647E+01	5.147E-04	1.316E-04	0.0
0.0175	1.461E+01	3.953E-03	1.461E+01	6.761E-04	1.492E-04	0.0
0.0200	1.317E+01	3.963E-03	1.318E+01	8.566E-04	1.663E-04	0.0
0.0250	1.109E+01	3.974E-03	1.110E+01	1.272E-03	1.990E-04	0.0
0.0300	9.653E+00	3.984E-03	9.657E+00	1.756E-03	2.301E-04	0.0
0.0350	8.592E+00	3.994E-03	8.596E+00	2.306E-03	2.599E-04	0.0
0.0400	7.777E+00	4.005E-03	7.781E+00	2.919E-03	2.886E-04	0.0
0.0450	7.130E+00	4.018E-03	7.134E+00	3.591E-03	3.165E-04	0.0
0.0500	6.603E+00	4.031E-03	6.607E+00	4.320E-03	3.435E-04	0.0
0.0550	6.166E+00	4.046E-03	6.170E+00	5.103E-03	3.698E-04	0.0
0.0600	5.797E+00	4.062E-03	5.801E+00	5.940E-03	3.955E-04	0.0
0.0700	5.207E+00	4.098E-03	5.211E+00	7.762E-03	4.452E-04	0.0
0.0800	4.757E+00	4.138E-03	4.762E+00	9.773E-03	4.931E-04	0.0
0.0900	4.402E+00	4.181E-03	4.407E+00	1.196E-02	5.393E-04	0.0
0.1000	4.115E+00	4.228E-03	4.120E+00	1.431E-02	5.841E-04	0.0
0.1250	3.591E+00	4.355E-03	3.596E+00	2.083E-02	6.912E-04	0.0
0.1500	3.238E+00	4.494E-03	3.242E+00	2.817E-02	7.926E-04	0.0
0.1750	2.984E+00	4.643E-03	2.988E+00	3.622E-02	8.894E-04	0.0
0.2000	2.793E+00	4.801E-03	2.798E+00	4.487E-02	9.826E-04	0.0
0.2500	2.528E+00	5.141E-03	2.533E+00	6.372E-02	1.161E-03	0.0
0.3000	2.355E+00	5.514E-03	2.360E+00	8.421E-02	1.331E-03	0.0
0.3500	2.235E+00	5.913E-03	2.241E+00	1.060E-01	1.496E-03	0.0
0.4000	2.148E+00	6.339E-03	2.154E+00	1.288E-01	1.658E-03	0.0
0.4500	2.083E+00	6.787E-03	2.090E+00	1.523E-01	1.818E-03	0.0
0.5000	2.034E+00	7.257E-03	2.041E+00	1.766E-01	1.976E-03	0.0
0.5500	1.995E+00	7.747E-03	2.003E+00	2.013E-01	2.134E-03	1.103E-02
0.6000	1.963E+00	8.254E-03	1.972E+00	2.265E-01	2.292E-03	2.938E-02
0.7000	1.917E+00	9.312E-03	1.926E+00	2.778E-01	2.608E-03	7.435E-02
0.8000	1.886E+00	1.043E-02	1.896E+00	3.302E-01	2.928E-03	1.267E-01
0.9000	1.864E+00	1.159E-02	1.876E+00	3.832E-01	3.251E-03	1.835E-01
1.0000	1.849E+00	1.280E-02	1.862E+00	4.367E-01	3.579E-03	2.428E-01
1.2500	1.829E+00	1.600E-02	1.845E+00	5.717E-01	4.416E-03	3.944E-01
1.5000	1.822E+00	1.942E-02	1.841E+00	7.075E-01	5.281E-03	5.437E-01
1.7500	1.821E+00	2.303E-02	1.844E+00	8.432E-01	6.171E-03	6.866E-01
2.0000	1.824E+00	2.678E-02	1.850E+00	9.785E-01	7.085E-03	8.218E-01
2.5000	1.834E+00	3.468E-02	1.868E+00	1.247E+00	8.969E-03	1.069E+00
3.0000	1.846E+00	4.299E-02	1.889E+00	1.514E+00	1.092E-02	1.288E+00
3.5000	1.858E+00	5.164E-02	1.910E+00	1.777E+00	1.291E-02	1.484E+00
4.0000	1.870E+00	6.058E-02	1.931E+00	2.037E+00	1.495E-02	1.660E+00
4.5000	1.882E+00	6.976E-02	1.951E+00	2.295E+00	1.702E-02	1.821E+00
5.0000	1.892E+00	7.917E-02	1.971E+00	2.550E+00	1.911E-02	1.967E+00
5.5000	1.902E+00	8.876E-02	1.991E+00	2.802E+00	2.123E-02	2.102E+00
6.0000	1.911E+00	9.854E-02	2.010E+00	3.052E+00	2.336E-02	2.227E+00
7.0000	1.928E+00	1.185E-01	2.047E+00	3.545E+00	2.766E-02	2.453E+00
8.0000	1.943E+00	1.391E-01	2.082E+00	4.030E+00	3.200E-02	2.652E+00
9.0000	1.956E+00	1.601E-01	2.116E+00	4.506E+00	3.636E-02	2.831E+00
10.0000	1.968E+00	1.814E-01	2.149E+00	4.975E+00	4.072E-02	2.992E+00
12.5000	1.993E+00	2.362E-01	2.230E+00	6.117E+00	5.163E-02	3.341E+00
15.0000	2.014E+00	2.926E-01	2.306E+00	7.219E+00	6.243E-02	3.633E+00
17.5000	2.031E+00	3.501E-01	2.381E+00	8.286E+00	7.309E-02	3.885E+00
20.0000	2.046E+00	4.086E-01	2.454E+00	9.320E+00	8.355E-02	4.107E+00
25.0000	2.070E+00	5.277E-01	2.598E+00	1.130E+01	1.039E-01	4.487E+00
30.0000	2.089E+00	6.489E-01	2.738E+00	1.317E+01	1.233E-01	4.806E+00
35.0000	2.105E+00	7.716E-01	2.876E+00	1.496E+01	1.418E-01	5.082E+00
40.0000	2.118E+00	8.955E-01	3.013E+00	1.665E+01	1.594E-01	5.326E+00
45.0000	2.129E+00	1.021E+00	3.150E+00	1.828E+01	1.762E-01	5.544E+00
50.0000	2.139E+00	1.144E+00	3.286E+00	1.983E+01	1.923E-01	5.741E+00
55.0000	2.148E+00	1.273E+00	3.421E+00	2.132E+01	2.076E-01	5.921E+00
60.0000	2.156E+00	1.400E+00	3.556E+00	2.276E+01	2.222E-01	6.087E+00
70.0000	2.170E+00	1.654E+00	3.829E+00	2.547E+01	2.496E-01	6.383E+00
80.0000	2.182E+00	1.914E+00	4.096E+00	2.799E+01	2.747E-01	6.641E+00
90.0000	2.193E+00	2.173E+00	4.366E+00	3.035E+01	2.978E-01	6.871E+00

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APPENDIX E. (*Continued*)

Lithium Fluoride

ENERGY	STOPPING POWER COLLISION	STOPPING POWER RADIATIVE	STOPPING POWER TOTAL	CSDA RANGE	RADIATION YIELD	DENS. EFF. CORR. (DELTA)
MeV	MeV cm²/g	MeV cm²/g	MeV cm²/g	g/cm²		
0.0100	1.796E+01	3.678E-03	1.796E+01	3.181E-04	1.117E-04	0.0
0.0125	1.513E+01	3.712E-03	1.514E+01	4.704E-04	1.344E-04	0.0
0.0150	1.315E+01	3.735E-03	1.316E+01	6.480E-04	1.561E-04	0.0
0.0175	1.168E+01	3.750E-03	1.169E+01	8.501E-04	1.770E-04	0.0
0.0200	1.055E+01	3.762E-03	1.055E+01	1.076E-03	1.973E-04	0.0
0.0250	8.894E+00	3.779E-03	8.898E+00	1.594E-03	2.360E-04	0.0
0.0300	7.748E+00	3.792E-03	7.751E+00	2.198E-03	2.729E-04	0.0
0.0350	6.902E+00	3.804E-03	6.906E+00	2.883E-03	3.082E-04	0.0
0.0400	6.252E+00	3.815E-03	6.256E+00	3.645E-03	3.423E-04	0.0
0.0450	5.736E+00	3.827E-03	5.739E+00	4.480E-03	3.752E-04	0.0
0.0500	5.315E+00	3.840E-03	5.319E+00	5.386E-03	4.071E-04	0.0
0.0550	4.965E+00	3.853E-03	4.969E+00	6.359E-03	4.382E-04	0.0
0.0600	4.670E+00	3.867E-03	4.674E+00	7.397E-03	4.684E-04	0.0
0.0700	4.198E+00	3.898E-03	4.202E+00	9.659E-03	5.269E-04	0.0
0.0800	3.838E+00	3.932E-03	3.842E+00	1.215E-02	5.831E-04	0.0
0.0900	3.553E+00	3.970E-03	3.557E+00	1.486E-02	6.372E-04	0.0
0.1000	3.323E+00	4.011E-03	3.327E+00	1.777E-02	6.896E-04	0.0
0.1250	2.903E+00	4.125E-03	2.907E+00	2.584E-02	8.143E-04	0.0
0.1500	2.619E+00	4.253E-03	2.623E+00	3.492E-02	9.321E-04	0.0
0.1750	2.415E+00	4.392E-03	2.419E+00	4.486E-02	1.045E-03	0.0
0.2000	2.261E+00	4.540E-03	2.266E+00	5.555E-02	1.153E-03	0.0
0.2500	2.048E+00	4.863E-03	2.053E+00	7.881E-02	1.360E-03	6.058E-03
0.3000	1.907E+00	5.215E-03	1.912E+00	1.041E-01	1.558E-03	2.136E-02
0.3500	1.809E+00	5.592E-03	1.814E+00	1.310E-01	1.750E-03	3.978E-02
0.4000	1.737E+00	5.992E-03	1.743E+00	1.591E-01	1.939E-03	6.095E-02
0.4500	1.683E+00	6.412E-03	1.690E+00	1.883E-01	2.125E-03	8.445E-02
0.5000	1.642E+00	6.852E-03	1.649E+00	2.183E-01	2.310E-03	1.098E-01
0.5500	1.609E+00	7.308E-03	1.617E+00	2.489E-01	2.495E-03	1.367E-01
0.6000	1.583E+00	7.779E-03	1.591E+00	2.801E-01	2.679E-03	1.648E-01
0.7000	1.546E+00	8.765E-03	1.555E+00	3.437E-01	3.048E-03	2.236E-01
0.8000	1.521E+00	9.800E-03	1.530E+00	4.086E-01	3.419E-03	2.846E-01
0.9000	1.503E+00	1.088E-02	1.514E+00	4.743E-01	3.794E-03	3.467E-01
1.0000	1.491E+00	1.200E-02	1.504E+00	5.406E-01	4.173E-03	4.093E-01
1.2500	1.476E+00	1.499E-02	1.491E+00	7.077E-01	5.141E-03	5.644E-01
1.5000	1.471E+00	1.818E-02	1.489E+00	8.756E-01	6.138E-03	7.142E-01
1.7500	1.471E+00	2.154E-02	1.493E+00	1.043E+00	7.163E-03	8.568E-01
2.0000	1.474E+00	2.505E-02	1.499E+00	1.210E+00	8.214E-03	9.917E-01
2.5000	1.483E+00	3.244E-02	1.515E+00	1.542E+00	1.038E-02	1.240E+00
3.0000	1.493E+00	4.021E-02	1.533E+00	1.870E+00	1.262E-02	1.461E+00
3.5000	1.503E+00	4.830E-02	1.552E+00	2.194E+00	1.491E-02	1.660E+00
4.0000	1.513E+00	5.666E-02	1.570E+00	2.515E+00	1.725E-02	1.839E+00
4.5000	1.523E+00	6.524E-02	1.588E+00	2.832E+00	1.962E-02	2.003E+00
5.0000	1.531E+00	7.402E-02	1.605E+00	3.145E+00	2.202E-02	2.154E+00
5.5000	1.539E+00	8.298E-02	1.622E+00	3.455E+00	2.444E-02	2.293E+00
6.0000	1.547E+00	9.211E-02	1.639E+00	3.761E+00	2.687E-02	2.422E+00
7.0000	1.560E+00	1.108E-01	1.671E+00	4.365E+00	3.178E-02	2.655E+00
8.0000	1.572E+00	1.299E-01	1.702E+00	4.958E+00	3.672E-02	2.861E+00
9.0000	1.583E+00	1.494E-01	1.732E+00	5.541E+00	4.168E-02	3.046E+00
10.0000	1.592E+00	1.693E-01	1.761E+00	6.113E+00	4.663E-02	3.214E+00
12.5000	1.612E+00	2.201E-01	1.832E+00	7.504E+00	5.894E-02	3.577E+00
15.0000	1.629E+00	2.723E-01	1.901E+00	8.844E+00	7.108E-02	3.881E+00
17.5000	1.642E+00	3.256E-01	1.968E+00	1.014E+01	8.299E-02	4.143E+00
20.0000	1.654E+00	3.797E-01	2.034E+00	1.139E+01	9.463E-02	4.374E+00
25.0000	1.673E+00	4.896E-01	2.163E+00	1.377E+01	1.171E-01	4.769E+00
30.0000	1.688E+00	6.014E-01	2.289E+00	1.602E+01	1.384E-01	5.099E+00
35.0000	1.700E+00	7.146E-01	2.415E+00	1.814E+01	1.585E-01	5.383E+00
40.0000	1.711E+00	8.289E-01	2.540E+00	2.016E+01	1.776E-01	5.633E+00
45.0000	1.720E+00	9.441E-01	2.664E+00	2.208E+01	1.957E-01	5.856E+00
50.0000	1.728E+00	1.060E+00	2.788E+00	2.392E+01	2.129E-01	6.057E+00
55.0000	1.736E+00	1.177E+00	2.912E+00	2.567E+01	2.292E-01	6.240E+00
60.0000	1.742E+00	1.294E+00	3.036E+00	2.735E+01	2.447E-01	6.408E+00
70.0000	1.754E+00	1.530E+00	3.283E+00	3.052E+01	2.735E-01	6.707E+00
80.0000	1.764E+00	1.767E+00	3.531E+00	3.346E+01	2.998E-01	6.968E+00
90.0000	1.772E+00	2.006E+00	3.778E+00	3.619E+01	3.238E-01	7.199E+00

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APPENDIX E. (*Continued*)

Teflon

ENERGY	STOPPING POWER COLLISION	STOPPING POWER RADIATIVE	TOTAL	CSDA RANGE	RADIATION YIELD	DENS.EFF. CORR. (DELTA)
MeV	MeV cm²/g	MeV cm²/g	MeV cm²/g	g/cm²		
0.0100	1.843E+01	4.211E-03	1.843E+01	3.105E-04	1.249E-04	0.0
0.0125	1.553E+01	4.247E-03	1.554E+01	4.589E-04	1.502E-04	0.0
0.0150	1.351E+01	4.271E-03	1.351E+01	6.320E-04	1.743E-04	0.0
0.0175	1.200E+01	4.287E-03	1.201E+01	8.287E-04	1.975E-04	0.0
0.0200	1.084E+01	4.300E-03	1.084E+01	1.048E-03	2.199E-04	0.0
0.0250	9.141E+00	4.316E-03	9.146E+00	1.553E-03	2.629E-04	0.0
0.0300	7.965E+00	4.329E-03	7.970E+00	2.140E-03	3.037E-04	0.0
0.0350	7.098E+00	4.341E-03	7.102E+00	2.806E-03	3.428E-04	0.0
0.0400	6.430E+00	4.353E-03	6.435E+00	3.547E-03	3.805E-04	0.0
0.0450	5.900E+00	4.366E-03	5.904E+00	4.359E-03	4.169E-04	0.0
0.0500	5.468E+00	4.380E-03	5.472E+00	5.239E-03	4.522E-04	0.0
0.0550	5.109E+00	4.395E-03	5.113E+00	6.185E-03	4.865E-04	0.0
0.0600	4.806E+00	4.410E-03	4.810E+00	7.194E-03	5.200E-04	0.0
0.0700	4.321E+00	4.444E-03	4.325E+00	9.391E-03	5.847E-04	0.0
0.0800	3.951E+00	4.483E-03	3.955E+00	1.181E-02	6.467E-04	0.0
0.0900	3.658E+00	4.525E-03	3.663E+00	1.444E-02	7.065E-04	0.0
0.1000	3.421E+00	4.571E-03	3.426E+00	1.727E-02	7.643E-04	0.0
0.1250	2.989E+00	4.700E-03	2.994E+00	2.511E-02	9.021E-04	0.0
0.1500	2.697E+00	4.844E-03	2.702E+00	3.392E-02	1.032E-03	0.0
0.1750	2.487E+00	5.000E-03	2.492E+00	4.357E-02	1.156E-03	0.0
0.2000	2.330E+00	5.167E-03	2.335E+00	5.395E-02	1.275E-03	0.0
0.2500	2.111E+00	5.530E-03	2.117E+00	7.651E-02	1.503E-03	0.0
0.3000	1.968E+00	5.928E-03	1.974E+00	1.010E-01	1.721E-03	0.0
0.3500	1.869E+00	6.353E-03	1.875E+00	1.271E-01	1.931E-03	0.0
0.4000	1.797E+00	6.805E-03	1.804E+00	1.543E-01	2.137E-03	2.294E-03
0.4500	1.742E+00	7.279E-03	1.749E+00	1.824E-01	2.341E-03	2.338E-02
0.5000	1.699E+00	7.775E-03	1.707E+00	2.114E-01	2.543E-03	4.753E-02
0.5500	1.665E+00	8.291E-03	1.674E+00	2.410E-01	2.744E-03	7.398E-02
0.6000	1.639E+00	8.823E-03	1.647E+00	2.711E-01	2.945E-03	1.022E-01
0.7000	1.600E+00	9.937E-03	1.610E+00	3.326E-01	3.347E-03	1.623E-01
0.8000	1.573E+00	1.111E-02	1.585E+00	3.952E-01	3.753E-03	2.253E-01
0.9000	1.555E+00	1.233E-02	1.568E+00	4.587E-01	4.162E-03	2.896E-01
1.0000	1.543E+00	1.360E-02	1.557E+00	5.227E-01	4.575E-03	3.541E-01
1.2500	1.527E+00	1.697E-02	1.544E+00	6.841E-01	5.631E-03	5.127E-01
1.5000	1.522E+00	2.057E-02	1.542E+00	8.462E-01	6.719E-03	6.637E-01
1.7500	1.522E+00	2.437E-02	1.546E+00	1.008E+00	7.837E-03	8.056E-01
2.0000	1.525E+00	2.834E-02	1.553E+00	1.169E+00	8.983E-03	9.382E-01
2.5000	1.535E+00	3.667E-02	1.572E+00	1.490E+00	1.134E-02	1.178E+00
3.0000	1.546E+00	4.544E-02	1.592E+00	1.806E+00	1.377E-02	1.390E+00
3.5000	1.558E+00	5.456E-02	1.612E+00	2.118E+00	1.626E-02	1.578E+00
4.0000	1.569E+00	6.399E-02	1.633E+00	2.426E+00	1.879E-02	1.748E+00
4.5000	1.579E+00	7.367E-02	1.653E+00	2.730E+00	2.136E-02	1.902E+00
5.0000	1.589E+00	8.357E-02	1.672E+00	3.031E+00	2.395E-02	2.043E+00
5.5000	1.598E+00	9.367E-02	1.692E+00	3.328E+00	2.656E-02	2.173E+00
6.0000	1.606E+00	1.040E-01	1.710E+00	3.622E+00	2.919E-02	2.294E+00
7.0000	1.621E+00	1.250E-01	1.746E+00	4.201E+00	3.447E-02	2.512E+00
8.0000	1.635E+00	1.466E-01	1.781E+00	4.768E+00	3.978E-02	2.706E+00
9.0000	1.646E+00	1.686E-01	1.815E+00	5.324E+00	4.509E-02	2.880E+00
10.0000	1.657E+00	1.910E-01	1.848E+00	5.870E+00	5.040E-02	3.039E+00
12.5000	1.679E+00	2.483E-01	1.927E+00	7.194E+00	6.355E-02	3.385E+00
15.0000	1.697E+00	3.071E-01	2.004E+00	8.466E+00	7.648E-02	3.677E+00
17.5000	1.712E+00	3.672E-01	2.079E+00	9.691E+00	8.913E-02	3.930E+00
20.0000	1.724E+00	4.281E-01	2.152E+00	1.087E+01	1.015E-01	4.155E+00
25.0000	1.745E+00	5.521E-01	2.297E+00	1.312E+01	1.252E-01	4.541E+00
30.0000	1.761E+00	6.781E-01	2.439E+00	1.523E+01	1.476E-01	4.866E+00
35.0000	1.774E+00	8.056E-01	2.579E+00	1.723E+01	1.687E-01	5.146E+00
40.0000	1.785E+00	9.344E-01	2.719E+00	1.911E+01	1.886E-01	5.394E+00
45.0000	1.795E+00	1.064E+00	2.859E+00	2.091E+01	2.075E-01	5.614E+00
50.0000	1.803E+00	1.195E+00	2.998E+00	2.262E+01	2.253E-01	5.814E+00
55.0000	1.811E+00	1.326E+00	3.137E+00	2.425E+01	2.421E-01	5.996E+00
60.0000	1.818E+00	1.458E+00	3.276E+00	2.580E+01	2.581E-01	6.163E+00
70.0000	1.830E+00	1.724E+00	3.554E+00	2.874E+01	2.878E-01	6.461E+00
80.0000	1.840E+00	1.991E+00	3.831E+00	3.144E+01	3.147E-01	6.721E+00
90.0000	1.849E+00	2.260E+00	4.109E+00	3.396E+01	3.392E-01	6.952E+00

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